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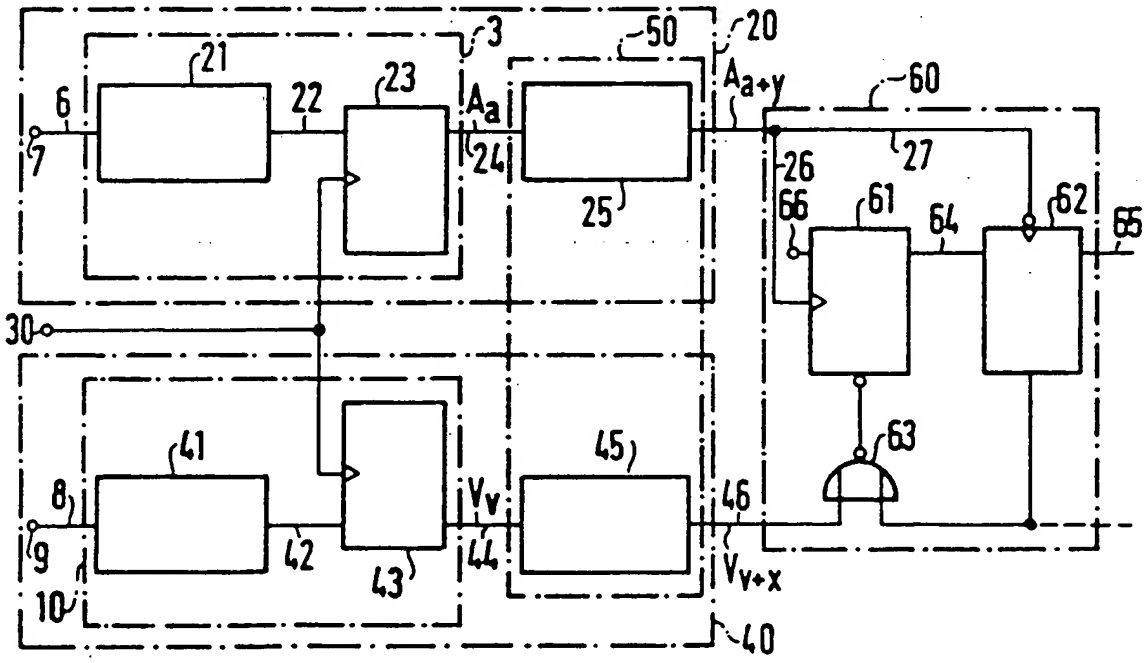
(54) Device for identifying atrial depolarization.

(57) A device for identifying an event, among atrial events sensed in a heart, as an atrial depolarization. An atrial detector (3) emits a first signal when an event is sensed in the atrium, and a ventricular detector (11) emits a second signal when an event is sensed in the ventricle. A window generator (50) creates a time window with the first signal inside the window, and a comparator (60) determines whether the second signal is inside or outside the window. If the second signal is outside the window, an identification signal (ID) for the atrial depolarization is emitted. In subsequent circuits in the device, an event sensed in the atrium can be indicated as e.g. atrial flutter or a cross-talk QRS. The indications can be used for controlling a heart stimulator.

FIG 2



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This invention relates to a device according to the preambula of patent claim 1 for identifying an event, among atrial events in a heart, as an atrial depolarization.

An atrial depolarization manifests itself as a P wave when cardiac activity is recorded in an ECG. The corresponding depolarization in the ventricle gives rise to a QRS complex or an R wave in the ECG. In e.g. physiological studies or in the treatment of the heart with an electrical heart stimulator such as a defibrillator, pacemaker etc., reliable identification of an atrial depolarization among events sensed in the atrium is important in many cases.

However, reliable identification of the P wave is a problem, as illustrated below with an example from dual-chamber pacing. A dual chamber pacemaker can operate in different modes, usually designated with a three-position alphabetic code in which the first letter indicates stimulation in the atrium (A), ventricle (V) or both (D), the second letter indicates sensing in the atrium (A), ventricle (V) or both (D) and the third letter indicates the pacemaker's operating mode, i.e. triggered (T), inhibited (I) or both (D). For the sake of simplicity, these alphabetic designations will be used where appropriate in the description below, the letter A thus generally designating the atrium.

Thus, a dual chamber pacemaker operating in the DDD mode stimulates and senses in both the atrium and the ventricle, and its mode is either inhibited or triggered as needed. In the inhibited mode, the pacemaker's stimulation pulse is suppressed in the case of the atrium when a P wave is sensed, and in the case of the ventricle when a QRS complex or R wave is sensed. In other words, the pacemaker only stimulates if the heart's intrinsic signals are not sensed at the right time.

The correct operation of such a dual chamber pacemaker obviously depends on the ability of the pacemaker's sensing electronics to accurately sense the P wave for the atrium (atrial channel) and the R wave for the ventricle (ventricular channel), respectively. However, this is not always the case because of interference, and pacemaker operation can then be affected. Sources of interference may be both inside and outside the heart and can affect sensing in both the atrial channel and the ventricular channel.

The object of the present invention is to achieve reliable identification of the P wave, therefore only interference problems in the atrium/atrial channel will be exemplified below.

One problem in the sensing of the P wave is caused by the circumstance that the QRS complex or R wave generated by the ventricle has an amplitude greatly exceeding the amplitude of the P wave. So when cross-talk occurs in the heart, the R wave causes detection of a spurious P wave in the atrium with an amplitude which is equal to or often greater than the amplitude of the true P wave. Here, "cross-talk" means that the R wave is propagated to the atrium by electrical conduction in blood and tissue and sensed there by the pacemaker's sensing electronics, i.e. far-field sensing of the R wave. The propagation time for the P wave in this context is on the order of 10 milliseconds. (For the sake of clarity, it should be noted that R wave cross-talk should be distinguished from retrograde conduction of the R wave to the atrium. In retrograde conduction, the myocardium's cells depolarize, and propagation time is on the order of 100 milliseconds. Retrograde conduction can also give rise to spurious P waves, but this phenomenon will not be discussed here.) A spurious P wave occurring in cross-talk can fool the pacemaker into emitting a stimulation pulse in the ventricle at a time corresponding to its repolarization, since the spurious wave occurs at a time corresponding to the R wave and not to atrial depolarization. In repolarization, which causes a T wave in the ECG, the ventricle is sensitive (the vulnerable phase) to electrical stimulation, and a pacemaker pulse delivered to the ventricle at this time could induce tachycardia or, at worst, fibrillation. These conditions are capable of causing cardiac arrest.

As noted above, other sources of interference can cause problems in the sensing of the P wave. Interference generated by e.g. external electrical equipment can, through far-field sensing, cause spurious P wave sensing. Susceptibility to spurious P wave sensing related to far-field sensing depends on electrode placement in the atrium. The risk of spurious P wave sensing is particularly great if a separate electrode, affixed to the wall of the atrium, is not used for sensing, as can occur in the VDD mode (when the atrium is only sensed, not stimulated), but the electrode cable, whose tip is in the ventricle, is instead provided with electrode surfaces for sensing in the atrium, these electrode surfaces located so a "floating" electrode results, i.e. the electrode is freely immersed in the blood of the atrium.

The prior art comprises a plurality of ways to avoid identification of spurious P waves as genuine. A spurious P wave often has e.g. a different frequency content or appearance (morphology) than a genuine P wave. So filtering or some other form of signal conditioning has been used for discriminating spurious P waves. However, ECG signals do not have the same morphology in different patients. This is e.g. because of the differing size and shape of the heart and/or differing placement of electrodes in different patients. In addition, ECG signals from one and the same patient may have different morphologies at different times because of e.g.

different transient pathological conditions in her his heart and/or medication given to treat these conditions. In a heart, ventricular extrasystoles acting on the atrium, such as PVC's (premature ventricular contractions), also have a morphology which greatly differs from a normal QRS. As a result of these variations in ECG signals, properly set sensing electronics, operating with filtration or morphology-processing signal conditioning capable of reliably identifying a genuine P wave on a particular occasion in a particular patient, may be totally incapable of achieving this identification in the same patient, or another patient, on another occasion.

Another way to avoid the sensing of spurious P waves is to impose a PVARP (post-ventricular atrial refractory period) with a duration suitable for the atrial channel's sensing electronics, after a spontaneous or stimulated QRS complex is sensed in the ventricle. The PVARP is achieved by blanking, i.e. the atrial channel's electronics are made insensitive by e.g. cutting off its supply of power. A blanking interval should be selected which is so long that atrial events capable of triggering stimulation in the ventricle during the vulnerable phase cannot be sensed. However, the interval must not be too long, since enough time must be left for the electronics to sense any genuine P wave for inhibition of the pacemaker before the pacemaker, in the DDD mode, triggers an atrial stimulation. However, the choice of an appropriate or optimum length for the blanking interval is often unfortunately associated with difficulties similar to those in the above described morphological and filtering technics and therefore depends on both the choice of patient and the individual patient's condition on a particular occasion. In recent years, attempts have been made to resolve the difficulty in finding an optimum interval by introduction of a two-part blanking interval for the electronics, the first part of which an absolute refractory period (initial blanking interval) and the second part a relative refractory period, the blanking interval restarting if a signal is sensed during the relative refractory part of the blanking interval. This technic, in which prolongation of the blanking interval can be achieved up to a certain period of time after blanking is instituted the first time, is described in US-A-4.974.589.

The present invention achieves a solution to the problem of reliable identification of an atrial depolarization by means of the features stated in the characterizing part of patent claim 1. If a check is made to ascertain whether a simple logical condition has been met for a signal from the atrium and a signal from the ventricle, the abovedescribed problems are avoided as regards the PVARP and variations in ECG morphology.

The invention is based on awareness that information which is available, or which can easily be obtained in a heart stimulator of the abovedescribed type, can be utilized for identifying atrial depolarization or the P wave.

A signal from an event sensed in the atrium, which can consist of a P wave, a QRS complex from the ventricle or some other electrical event, is compared in a procedure described below to a possible signal from the ventricle. If there is only a signal from the atrium at the time of this comparison, the signal represents a P wave. When there are concomitant signals from the atrium and the ventricle, the signal from the atrium represents a QRS complex. When there are a plurality of consecutive signals from both the atrium and the ventricle, the atrial signal represents external interference.

A heart stimulator, to which the invention is applied, can then be controlled to stimulate the heart in an appropriate way. If the heart stimulator is operating in the bradycardiatreatment mode, it can e.g. be inhibited when a QRS complex is present, stimulate in the ventricle with a suitable delay when a P wave is present and stimulate at a fixed rate when external interference is present. If the heart stimulator is in the tachycardia-treatment mode, it can, when P waves occur at an interval which is shorter than a defined interval and this interval e.g. serves as the criterion for atrial flutter or fibrillation, emit tachycardia-terminating stimulation pulses.

Advantageous embodiments of the invention are indicated in the sub-claims.

The invention, depicted in the attached drawings, will now be described in greater detail with the aid of an exemplified embodiment of the device as applied to a dual chamber pacemaker.

FIG. 1 shows a block diagram of a dual chamber pacemaker.

FIG. 2 shows, in a block diagram, the device according to the invention in a dual chamber pacemaker.

FIGS. 3A, 3B illustrates, in the form of a time diagram, the operation of the device according to FIG. 2.

FIG. 3C illustrates the functional time window of the device according to the invention.

FIG. 4 shows a flow chart of a function in the pacemaker's control device for evaluating the duration of intervals between certain emitted signals shown in FIG. 3.

FIG. 1 is a block diagram of a dual chamber pacemaker to which the device according to the invention can be applied. The dual chamber pacemaker 1 contains an atrial stimulation pulse generator 2, an atrial detector 3, a ventricular stimulation pulse generator 10, a ventricular detector 11, a

control device 4 and a telemetry unit 12. The atrial stimulation pulse generator 2 generates stimulation pulses, delivered to the atrium in a heart 5 via an atrial electrode lead 6 and an atrial electrode device 7 arranged thereon. The ventricular stimulation pulse 10 generates stimulation pulses, delivered to the ventricle in the heart 5 via a ventricular electrode lead 8 and a ventricular electrode device 9 arranged thereon. The pacemaker can sense events in the heart 5 by sensing electrical activity there. Electrical activity in the atrium is sensed by the atrial electrode device 7, sent in the form of a raw signal via the electrode lead 6 to the atrial detector 3 and emitted, after certain signal conditioning such as gain, in the form of an atrial output signal when an event occurs in the atrium. Electrical activity in the ventricle is sensed by the ventricular electrode device 9, sent in the form of a raw signal via the electrode lead 8 to the ventricular detector 11 and emitted, after certain signal conditioning such as gain, in the form of a ventricular output signal when an event occurs in the ventricle. Both the atrial and ventricular output signals are sent to the control device 4 in which they are analyzed by the device according to the invention in a procedure described below for determining whether the atrial output signal was emitted as a response to atrial depolarization. The control device 4, which can consist of a micro-processor, contains e.g. a clock frequency-generating time base generator (30;FIG.2) or a clock and a number of logic circuits. The control device 4 synchronizes the different units in the pacemaker with one another and also controls the units on the basis of events detected in the heart 5. Using an external programming unit 13, an operator/physician can check on and even change settings in the pacemaker 1. Communications between the pacemaker 1 and the external programming unit 13 are via the telemetry unit 12.

FIG. 2 shows a block diagram of the atrial and ventricular detection channels plus the function blocks which analyze the output signal from the atrial detector 3 and which, according to the invention, emit an identification signal for atrial depolarization.

The atrial channel 20 contains the atrial electrode device 7 shown in FIG. 1, the atrial detector 3 also shown in FIG. 1 and an atrial pulse-prolonging circuit 25. The atrial detector 3 consists of a level detector 21 (or some other kind of detector) and a flip-flop 23. The ventricular channel 40 contains the ventricular electrode device 9 shown in FIG. 1, the ventricular detector 10 also shown in FIG. 1 and a ventricular pulse-prolonging circuit 45. The ventricular detector 10 consists of a level detector 41 (or some other kind of detector) and a flip-flop 43. The output terminal of the level detector 21 in the atrial detector 3 is connected to an input terminal of the flip-flop 23 via the line 22, and the output terminal of the flip-flop 23 is connected via the line 24 to the input terminal of the atrial pulse-prolonging circuit 25. In the ventricular channel 40, corresponding elements 41, 43 and 45 are connected in an analogous manner via lines 42 and 44. The flip-flops 23 and 43 are synchronized with the clock frequency set by the time base generator 30. The flip-flop 23 generates the output signal of the atrial detector 3 on line 24 in the form of an atrial stimulation pulse A with a duration, designated a, governed by the sensed event. The atrial pulse-prolonging circuit 25 prolongs the atrial pulse A by an optional value y, so the prolonged atrial pulse emitted on lines 26 and 27 has a total duration of $a + y$. The flip-flop 43 generates the output signal of the ventricular detector 10 on line 44 in the form of a ventricular stimulation pulse V with a duration, designated v, governed by the sensed event. The ventricular pulse-prolonging circuit 45 prolongs the ventricular pulse V by an optional value x so the prolonged ventricular pulse emitted on line 46 has a total duration of $v + x$. The atrial pulse-prolonging circuit 25 and the ventricular pulse-prolonging circuit 45 jointly form a window generator 50 which generates a time window for events sensed in the heart 5 (FIG. 3C). The window generator 50 is followed by a comparator 60. The comparator 60 comprises a flip-flop 61, a shift register 62 and a NOR gate 63. The flip-flop 61, one input terminal 66 of which normally has a high level, is connected to the shift register 62 via the line 64, and the shift register 62 has a line 65 connecting the shift register 62 to other logic circuits in the control device 4. The control device 4 is also connected (dashed line) to the reset input terminal of the shift register 62 and, via the NOR gate 63, to the reset input terminal of the flip-flop 61. The length (width) of pulses will be designated below with an index.

The function of the device according to FIG. 2 is shown in an overview in FIG. 3A. In FIG. 3A, the time is indicated on the horizontal axis with a scale in which each marking on the axis designates 50 ms. The vertical axis in FIG. 3 indicates signal amplitude without the use of any particular scale and without the amplitude of the signals on different lines shown with a correct inter-signal relationship. Nor are the signals shown on the same line on lines 1 and 2 intended to depict correct inter-signal magnitudes or to jointly encompass all parts of the ECG signal. So the object of FIG. 3 is solely to supply an overview of signals important to the invention. On line 1 is shown the electrical activity AE sensed by the atrial electrode 7. On line 2 is shown the electrical activity VE sensed by the ventricular electrode 9. On line 3 is shown the atrial pulses A_a transmitted on line 24 after the flip-flop

23. On line 4 is shown the ventricular pulses V_v transmitted on line 44 after the flip-flop 43. On line 5 is shown the prolonged atrial pulses A_{a+y} transmitted on lines 26, 27 after the atrial pulse-prolonging circuit 25, and on line 6 is shown the prolonged ventricular pulses V_{v+x} on line 46 after the ventricular pulse-prolonging circuit 45. On line 7 is shown the output pulses transmitted on line 64 from the flip-flop 61 in the comparator 60, and on line 8 is shown the identification signals ID for atrial depolarizations transmitted on line 65 after the shift register 62. Finally, on line 9 is shown reset pulses from the control device for the flip-flop 61 and the shift register 62.

When a genuine P wave, e.g. P1 (line 1), is sensed by the atrial electrode 7, the flip-flop 23 generates a pulse A_a with pulse width a. The pulse A_a is prolonged in the pulse-prolonging circuit 25 by a value y, e.g. 10 ms, so the total width of the prolonged atrial pulse A_{a+y} is a+y. The positive flank of the pulse A_{a+y} sets, as designated by the vertical arrow on line 5, the flip-flop 61 in the comparator 60 to a high level by shifting the input terminal 66 to "1" or a high level so the signal (line 7) arriving at the shift register 62 on line 64 goes high. On the negative flank of the pulse A_{a+y},received by the shift register 62 via the line 27, the high signal level of the shift register's input terminal 62 is sent to line 65, since no electrical activity VE (line 2) occurs in the ventricle during the pulse period A_{a+y}, which via the ventricular channel 40, can cause a reset pulse to be sent to the reset input terminal on the flip-flop 61. Thus, the high signal level on line 65 thereby constitutes an identification signal ID for atrial depolarization. The identification signal ID terminates, and the flip-flop 61 and shift register 62 are reset when the reset pulse (line 9) is emitted by the logic in the control device 4.

When a QRS complex, e.g. QRS1 (line 1), is sensed by the atrial electrode 7, the flip-flop 23 again generates an atrial pulse A_a, and this pulse is prolonged in the abovedescribed manner into a pulse with the pulse width A_{a+y}. However, the QRS complex QRS1 is also sensed by the ventricular electrode 9 (line 2), so the flip-flop 43 generates a ventricular pulse V_v which is prolonged in the pulse-prolonging circuit 45 by a value x, e.g. 20 ms, resulting in a total pulse width of v+x for the pulse V_{v+x}. As lines 5 and 6 show, the reset pulse V_{v+x} and the setting pulse A_{a+y} are applied to the respective input terminals of flip-flop 61 with a time overlap so great that the flip-flop 61 cannot be set high by the positive flank of A_{a+y}.Thus, the shift register 62 reads a low level for the flip-flop 61 at the negative flank of the pulse A_{a+y}, and there is no identification signal ID for atrial depolarization.

The same applies to P2 and QRS2 as was described above for P1 and QRS1. A PVC is then sensed, i.e. a ventricular contraction without a preceding P wave. As FIG. 3A shows, the effect of a PVC is the same as for a QRS, i.e. there is no identification signal ID for atrial depolarization. At P3 the atrial electrode 7 again senses a genuine P wave. This wave is identified with an identification signal ID in the same way as described above for P1.

In FIG. 3B is shown the course of events in detail for the cardiac activities covered by P2, QRS2 and PVC in the overview FIG. 3A. The horizontal axis in FIG. 3B is expanded relative to the horizontal axis in FIG. 3A, although without being unequivocally related to the latter by a specific scale, since the main object of FIG. 3B is to clearly discriminate components in the functional course.

Detection of a P wave (P2) begins at time T_1, leading to a high level for the pulses A_a, A_{a-y}. As previously noted, the arrow on line 5 indicates that the positive flank of the pulse A_{a+y} sets the signal (line 7) arriving at the shift register 62 high. Detection of the P wave terminates at T_2, and the pulse A_a goes low. At T_3, i.e. y ms after a concluded P wave, the pulse A_{a+y} goes low, and its negative flank switches the identification signal ID to a high level (vertical arrow, line 8). A reset pulse (line 9) is emitted by the logic in the control device 4 at T_4, the signal on the line 64 and the ID then going low.

At T_5 detection of a QRS (QRS2) begins in the ventricle, causing the pulses V_v and V_{v+x} to go high. At T_6 detection of QRS2 (far-field) begins in the atrium, causing the pulses A_a and A_{a+y} to go high. At T_7 detection of QRS2 ends in the ventricle, and the pulse V_v goes low. At T_8, i.e. x ms after V_v, V_{v+x} goes low. At T_9 detection of QRS2 ends in the atrium, and A_a goes low. At T_{10}, i.e. y ms after A_a, A_{a+y} goes low. In this process, as previously noted, the pulses V_{v+x} and A_{a+y} have such a time overlap that no identification signal ID can appear.

The course of events for and effect of a PVC will be, as noted above, the same as for a QRS, even if, as shown in FIG. 3B, the morphology of a QRS and a PVC differs somewhat. The functional course of events at times T_{11} - T_{16} coincides with the course recently described for times T_5 - T_{10} and need not be repeated here. Thus, no identification signal ID appears with a PVC either.

In FIG. 3 is shown the function of the abovedescribed time window. Detection of an atrial event is always inside the window. A ventricular event detected in the window, i.e. within the period of time x ms before or y ms after detection of the atrial event, makes it impossible for the identification signal ID to appear. However, a ventricular event detected outside the window causes an iden-

tification signal ID to appear. The upper part of FIG. 3C shows a detection P on the atrial level A, and the lower part shows the ventricular window x + y belonging to atrial detection on the ventricular level V.

In a subsequent logic circuit arranged in the control device 4, preferably part of the microprocessor in the control device 4, the signals A_a, V_v and ID shown in FIG. 3A on lines 3, 4 and 8 are additionally processed to permit identification of the event sensed in the atrium. FIG. 4 shows a flow chart 70 of the additional processing. If an identification signal ID is present, function block 73 determines whether the interval between consecutive identification signals (ID (or atrial pulses A_a) is shorter or longer than a defined, optional reference interval, e.g. 240 ms. If shorter, block 75 indicates the presence of atrial flutter/fibrillation. If longer, block 74 indicates the presence of P waves with some other rhythm. If no identification signal ID is present, i.e. the pulses A_a (always inside the window) and V_v are both inside the time window, the determination moves to block 76 in the flow chart 70. Block 76 determines whether the interval between consecutive time windows with associated atrial pulses A_a and ventricular pulses V_v is longer or shorter than some other optional interval, e.g. 100 ms (the example 100 ms would correspond to a heart beating at a rate of 600 beats/ minute, an improbable rate with normal-frequency QRS complexes). If longer, block 78 indicates the presence of a QRS complex. If shorter, block 77 indicates the presence of interference external to the heart. Block 78 also ascertains whether an identification signal occurs before or after a ventricular event. If before, block 79 indicates the presence of a normal QRS. If after, block 80 indicates the presence of a PVC. It is now apparent that intervals other than those exemplified can be selected with other lengths in order to indicate other conditions in the heart. If desired, block 73 can identify e.g. other kinds of atrial tachycardias, in addition to flutter/fibrillation, when an interval longer than the one constituting the criterion for flutter/ fibrillation is imposed.

The circuit logic and/or program flows in the microprocessor in the control device 4 following after the flowchart in FIG. 4 for controlling, on the basis of the indications in blocks 74, 75 and 77, 78, the pulses emitted by the heart stimulator for e.g. treating atrial flutter or bradycardia are not described here, since they are not part of the invention and can easily be achieved by anyone with normal skill in the art. Anyone with normal skill in the art can also easily achieve modifications of parts shown in the block diagram in FIG. 2. For example, the level detectors 3 and 10 can be replaced, as noted above, with detectors which emit a pulse with a defined duration, independently of the duration of the event.

Claims

1. A device for identifying an event, among atrial events in a heart (5), as an atrial depolarization and comprising

   an atrial detector (3) which emits a first signal when there is an event in the atrium, and

   a ventricular detector (11) which emits a second signal when there is an event in the ventricle, **characterized in** that

   a window generator (50) creates a time window with the first signal inside the window, and

   a comparator (60) compares the second signal to the time window, emitting an identification signal (ID) for atrial depolarization when the second signal is outside the window.

2. A device of claim 1, wherein the atrial detector (3) designates the first signal as an atrial pulse.

3. A device of claim 2, wherein the window generator (50) has an atrial pulse-prolonging circuit (25) for prolonging the atrial pulse by a defined, selectable value.

4. A device of claims 1, 2 or 3, wherein the ventricular detector (11) designates the second signal as a ventricular pulse.

5. A device of claim 4, wherein the window generator (50) has a ventricular pulse-prolonging circuit (45) for prolonging the ventricular pulse by a defined, selectable value.

6. A device of claim 5, wherein the comparator (60) comprises a flip-flop (61) which, if the prolonged ventricular pulse is not received at a reset input terminal of same, is set at a first logical level by the prolonged atrial pulse's positive flank, and reset to a second logical level if the prolonged ventricular pulse is received at the reset input terminal of the flip-flop (61) during the duration of the prolonged atrial pulse and a shift circuit (62) which reads the state of the flip-flop (61) at the prolonged atrial pulse's negative flank and emits the identification signal (ID) for atrial depolarization in the form of a pulse if the flip-flop (61) then displays the first logical state.

7. A device as in any of claims 1 - 6, wherein consecutive first signals/atrial pulses (A_a)-/identification signals (ID) are examined, if an

identification signal (ID) is present, with respect to the interval between them, the events, corresponding to the first signals atrial pulses/identification signals, in one function block (75) being identified as atrial tachy-arrhythmia if the interval is shorter than an optional reference interval, and if the interval is longer than the reference interval in another function block (74) being indicated as P waves with another rhythm.

8. A device of claim 7, wherein the tachyarrhythmia is atrial flutter fibrillation.

9. A device of any of claims 1 - 6, wherein consecutive time windows with associated first signals/atrial pulses (A_a) and second signals/ventricular pulses (V_v) are examined, if no identification signal (ID) is present, with respect to the interval between them, whereupon events corresponding to the first signals atrial pulses are designated in a function block (78) as a QRS complex if this interval is longer than another optional reference interval, and events corresponding to the first signals/atrial pulses are designated in another function block (77) as external interference if this first interval is shorter than said other reference interval.

10. A device of claim 9, wherein the QRS complex is designated as a normal QRS complex in an additional function block (79) if the identification signal (ID) occurs before a ventricular event and is designated in another, additional function block (80) as a PVC if the identification signal (ID) occurs after a ventricular event.

11. A device of at least one of the preceding claims, wherein it is connected to a heart stimulator's (1) control device, (4), whereby the control device (4) controls the heart stimulator (1) on the basis of events identified/indicated by the device.

FIG 1

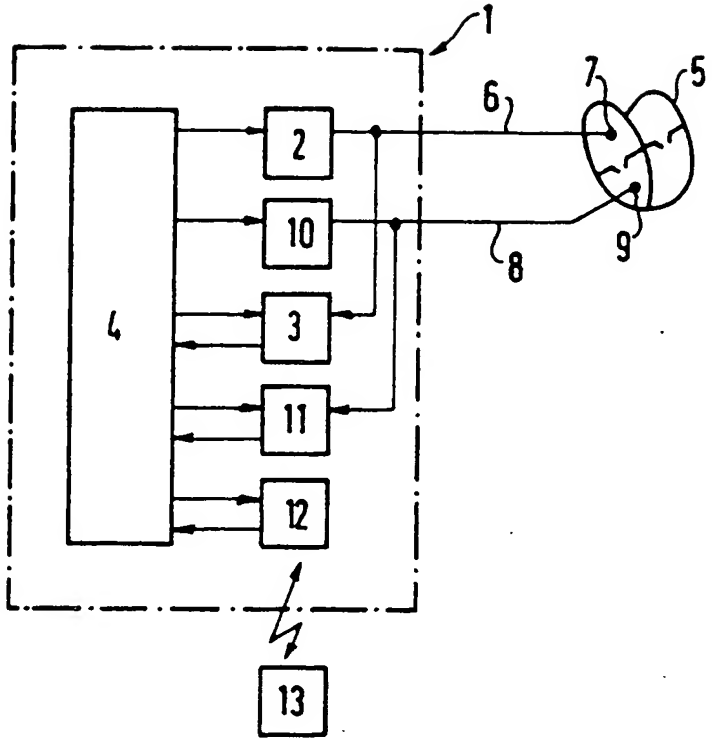
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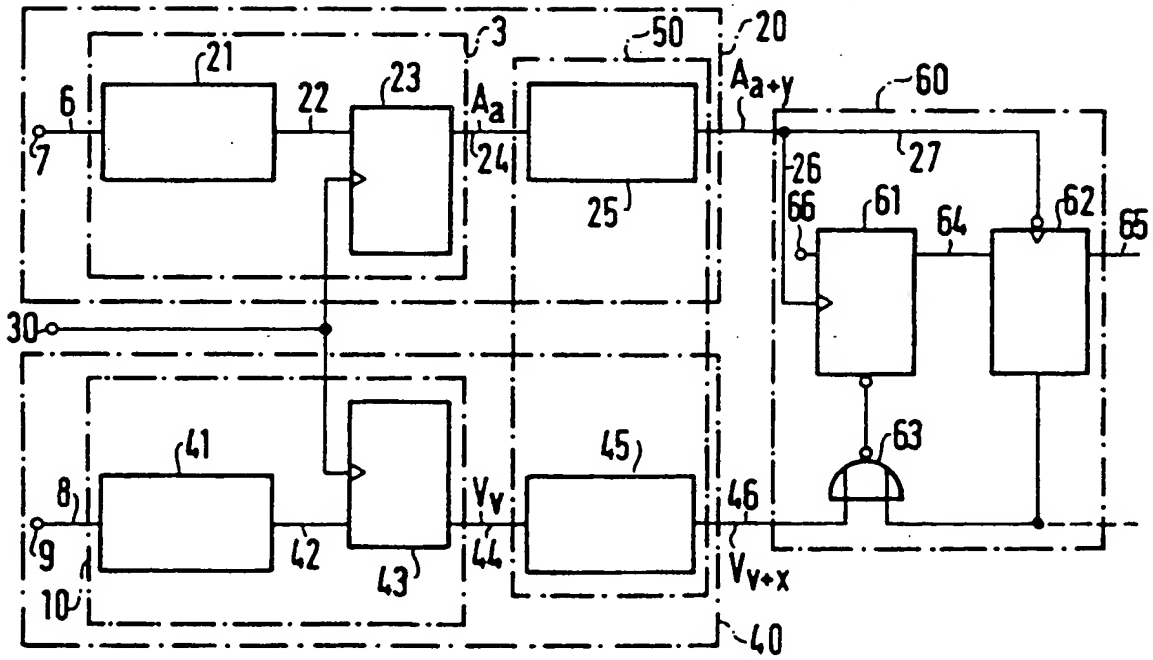
FIG 2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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93112608.0

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A- 5 010 887 (HANS T. THORNANDER) *figures 2,3; claim 1*	1-11	A61N 1/368 A61B 5/0452
A	US-A- 4 723 551 (SVEN-ERIK HEDBERG ET AL) *whole document*	1-11	
A	US-A- 4 712 554 (ARTHUR GARSON, JR) *column 3, line 13-line 30*	1-11	
A	US-A-4 917 115 (DAVID FLAMMANG ET AL) *whole document*	1-11	
A	WO-A1-9 213 596 (MEDTRONIC, INC) *whole document*	1-11	
A	US-A- 4 974 589 (JASON A. SHOLDER) *whole document*	1-11	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A61N
A61B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	20-01-1994	WIHLSSON. J

CATEGORY OF CITED DOCUMENTS

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